EXHIBIT A

12 pages

Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller

Expert Report of Dr. B. Engel

For
State of Oklahoma
In Case No. 05-CU-329-GKF-SAJ

State of Oklahoma v. Tyson Foods, et al.
(In the United States District Court for the Northern District of Oklahoma)

Dr. B. Engel, P.E.
Professor of Agricultural and Biological Engineering

May 22, 2008

Bernard Engel, Ph.D., P.E.

Figure 10.28. P Load Trend at Baron Fork near Eldon for Background Soil P Levels with No Poultry Waste Application in the IRW.
Figure 10.29. P Loads at Caney Creek for Background Soil P Levels with No Poultry Waste Application in the IRW.
Figure 10.30. P Load Trend at Caney Creek for Background Soil P Levels with No Poultry Waste Application in the IRW.
Figure 10.31. Modeled P Load and P Load Trend Line to Tahlequah from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production
Figure 10.32. Modeled P Load and P Load Trend Line to Baron Fork near Eldon from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production
Figure 10.33. Modeled P Load and P Load Trend Line to Caney Creek from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production
Figure 10.34. Modeled NPS P Load and NPS P Load Trend Line at Tahlequah from 1950 to 1999 Using IRW Poultry Production Data
Figure 10.35. Modeled NPS P Load and NPS P Load Trend Line to Baron Fork Near Eldon from 1950 to 1999 Using IRW Poultry Production Data
Figure 10.36. Modeled NPS P Load and NPS P Load Trend Line to Caney Creek from 1950 to 1999 Using IRW Poultry Production Data
Figure 10.37. Average P Concentrations for March-June Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data
Figure 10.38. Average P Concentrations for July-September Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data
Figure 10.39. Average P Concentrations for March-June Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data
Figure 10.40. Average P Concentrations for July-September Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data

Poultry House Density Correlated to Elevated P Levels in Runoff and Base Flow

The analyses of observed P in runoff and in baseflow for 14 small watersheds within the Illinois River Watershed that were sampled in 2005 and 2006 show a strong and statistically significant correlation between P in runoff and in baseflow and poultry house density. Sub-basin poultry house densities are strong predictors of stream total phosphorus concentration showing a cause and effect relationship between poultry house operations and phosphorus concentrations in IRW waters. From these analyses, it is evident that poultry waste is a substantial contributor to P in stream runoff and in the baseflow within streams of the Illinois River Watershed.

Hydrologic/Water Quality Modeling of Illinois River Watershed

1. The hydrologic/water quality model was able to accurately model the P loads to IRW rivers and streams and Lake Tenkiller.
2. For continued poultry waste application in the IRW at current levels, modeled P loads to Lake Tenkiller would increase during the first 30 years. For the next 70 years, P loads to Lake Tenkiller would decline slightly and stabilize at levels above current Lake Tenkiller P loads due to P saturation of soils.
3. Cessation of poultry waste application in the IRW would decrease P loads to Lake Tenkiller. The reductions in P loads to Lake Tenkiller due to poultry waste land application cessation would be limited to 16% during the first 10 years following cessation due to continued P load contributions from historical poultry waste application in the IRW that have elevated soil P. Following poultry waste land application cessation in the IRW, reductions in P loads to Lake Tenkiller would reach 50% by years 51-60.
4. For continued growth in the IRW poultry industry at a rate the same as that between 1982 and 2002, P loads to Lake Tenkiller would increase substantially. Within 40-50 years, P loads to Lake Tenkiller would nearly double (increase of 92%).
5. The addition of vegetated 100 foot buffers along all 3rd order and larger IRW streams combined with poultry waste application cessation in the IRW would provide further reductions of P loads of between 3 and 5% compared to poultry waste application cessation alone. The addition of vegetated 100 foot buffers along all IRW streams combined with poultry waste application cessation in the IRW would provide further reductions of P loads of between 10 and 13% compared to poultry waste application cessation alone.
6. P loads to Lake Tenkiller would be more than 275,000 lbs less than current levels (less than ½ of current levels) if poultry waste had never been disposed of in the IRW. It would take approximately 100 years of cessation of poultry waste application to return P loads in the IRW to what they would have been if no poultry waste land application had occurred.
7. P loads to Lake Tenkiller since 1954 have increased at approximately 10,000 lbs per year. Poultry waste application in the IRW is responsible for approximately 6,600 lbs of this increase each year.
8. Poultry waste land application in the IRW is a substantial contributor (45% between 1998 and 2006 and 59% between 2003 and 2006) to P loads to Lake Tenkiller, representing the largest P source. WWTP P loads are the second largest contributor to P loads to Lake Tenkiller. Poultry plant discharges to WWTP represent a significant portion of WWTP P loads.

operations in the IRW (years 1-10). Thus, even after 100 years of poultry waste application cessation in the IRW, the elevated soil P levels due to historic poultry waste application would continue to contribute to P loads to IRW waters.

Table 10.10. P Loads to IRW Waters with No Poultry Waste Application and Total P Load to Lake Tenkiller for Poultry Waste Application Cessation. Weather Repeats Every 10 Years So Results Are Summarized in 10 Year Periods.

	P Load (lbs)				
Years	Tahlequah	Baron	Caney	No Application Total	Total (Cessation)
1-10	1,593,185	517,044	183,305	2,293,534	4,343,485
11-20	1,577,197	418,569	191,028	2,186,795	4,019,937
21-30	1,416,532	360,511	177,237	1,954,279	3,658,654
31-40	1,316,867	305,908	162,427	1,785,203	3,315,579
41-50	1,232,647	268,748	149,734	1,651,129	3,093,820
51-60	1,155,226	245,471	136,380	1,537,077	2,895,368
61-70	1,112,297	238,307	132,631	1,483,235	2,737,468
71-80	1,077,848	225,995	130,736	1,434,579	2,588,668
81-90	1,057,895	208,819	128,060	1,394,774	2,498,852
91-100	1,044,273	192,647	127,000	1,363,920	2,437,254

10.6 Historical P Loads in Illinois River Watershed Streams and Rivers

P loads to Lake Tenkiller since 1954 have increased at approximately 10,000 lbs per year. Poultry waste application in the IRW is responsible for approximately 6,600 lbs of this increase each year.

P loads to the 3 gauging stations (Tahlequah, Baron Fork, and Caney Creek) were modeled using the same approach that has been used for modeling of results presented in prior sections. Soil P levels were assumed to be equivalent to current levels in Sequoyah County which would be considered equivalent to soil P levels for the entire watershed in 1950. WWTP P discharges were included as described in the WWTP section for 1950 through 1999 (Table 6.3). Poultry P applications to pastures in the IRW were based on historical poultry production in the watershed (Section 7).

Figures 10.31-10.33 show the modeled P loads from the IRW from 1950-1999. The trend line at the Tahlequah indicates P loads increase approximately 9,200 lbs/year and at Baron Fork by approximately 770 lbs/year. The Caney Creek watershed showed little change in P loads over this 50 year period, since its pastures received little poultry waste over this period.

Stow et al. (2001) computed historical nutrient loads in a watershed using a similar approach. Nutrient inputs to the watershed were computed for a more than 100 year period. WWTP nutrient inputs were computed using a similar approach as used within this report. Using the

nutrient inputs and historical nutrient trends in observed river water, nutrient concentrations were computed.

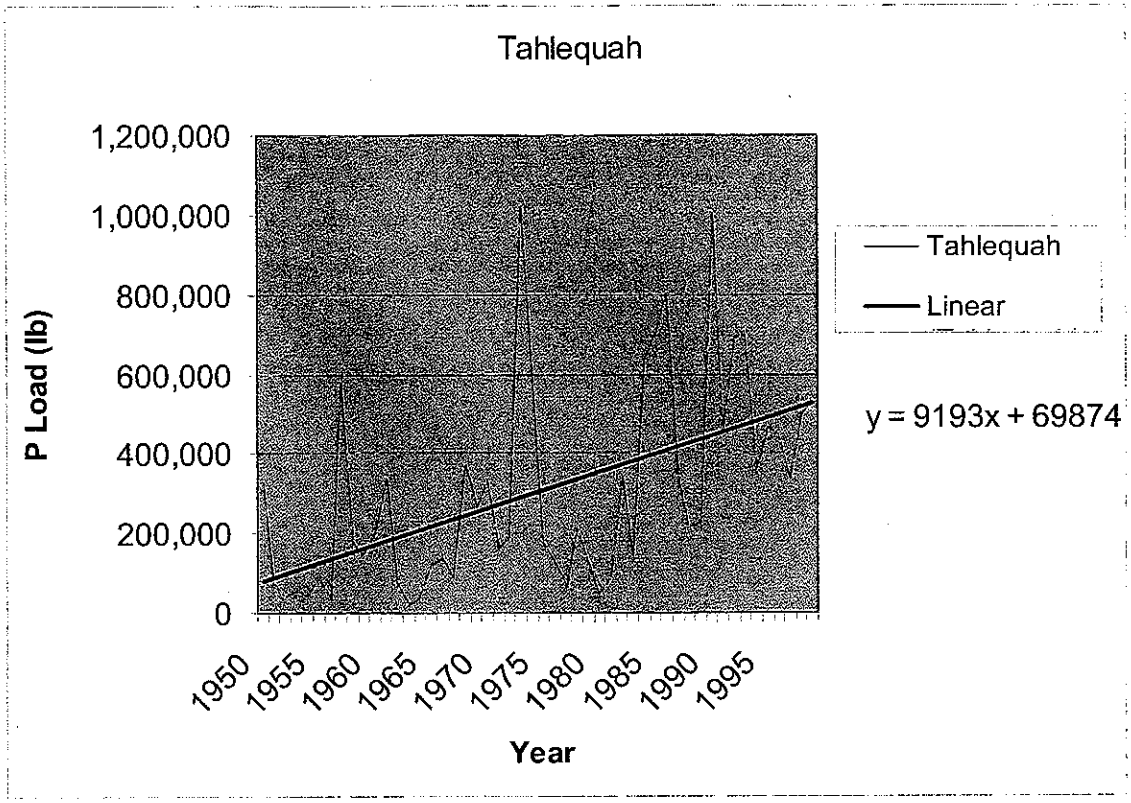

Figure 10.31. Modeled P Load and P Load Trend Line to Tahlequah from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

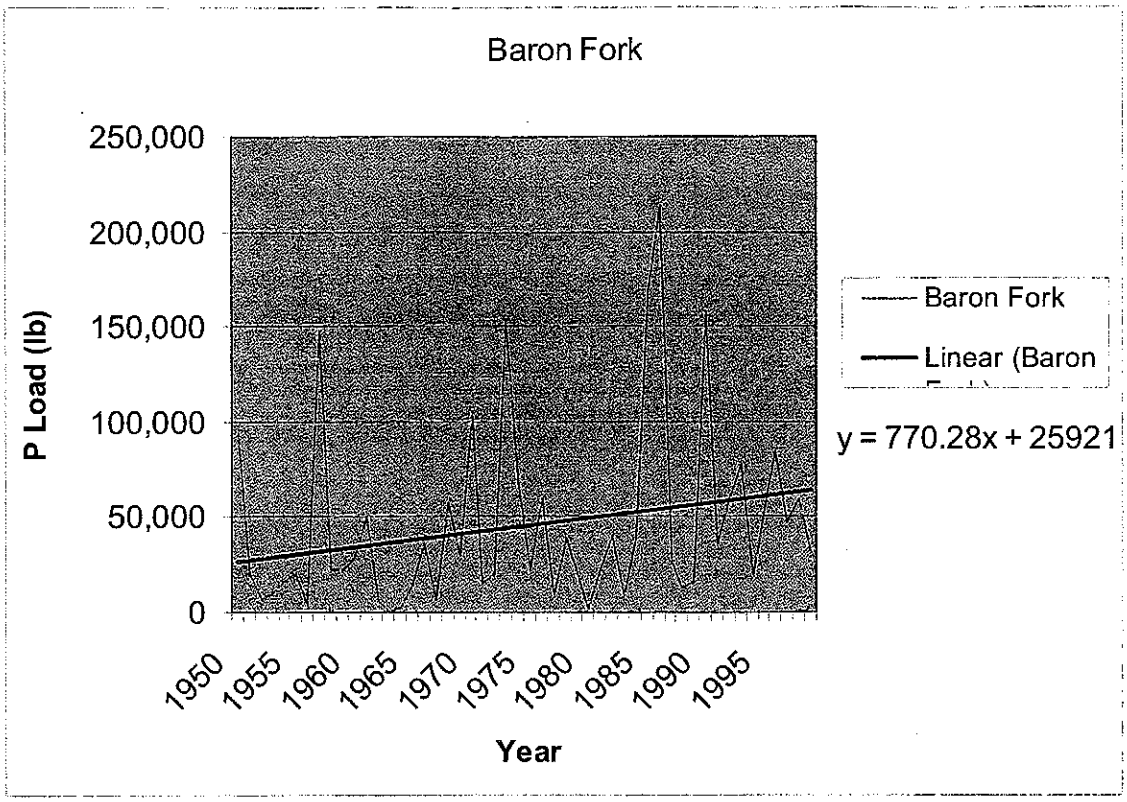

Figure 10.32. Modeled P Load and P Load Trend Line to Baron Fork near Eldon from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

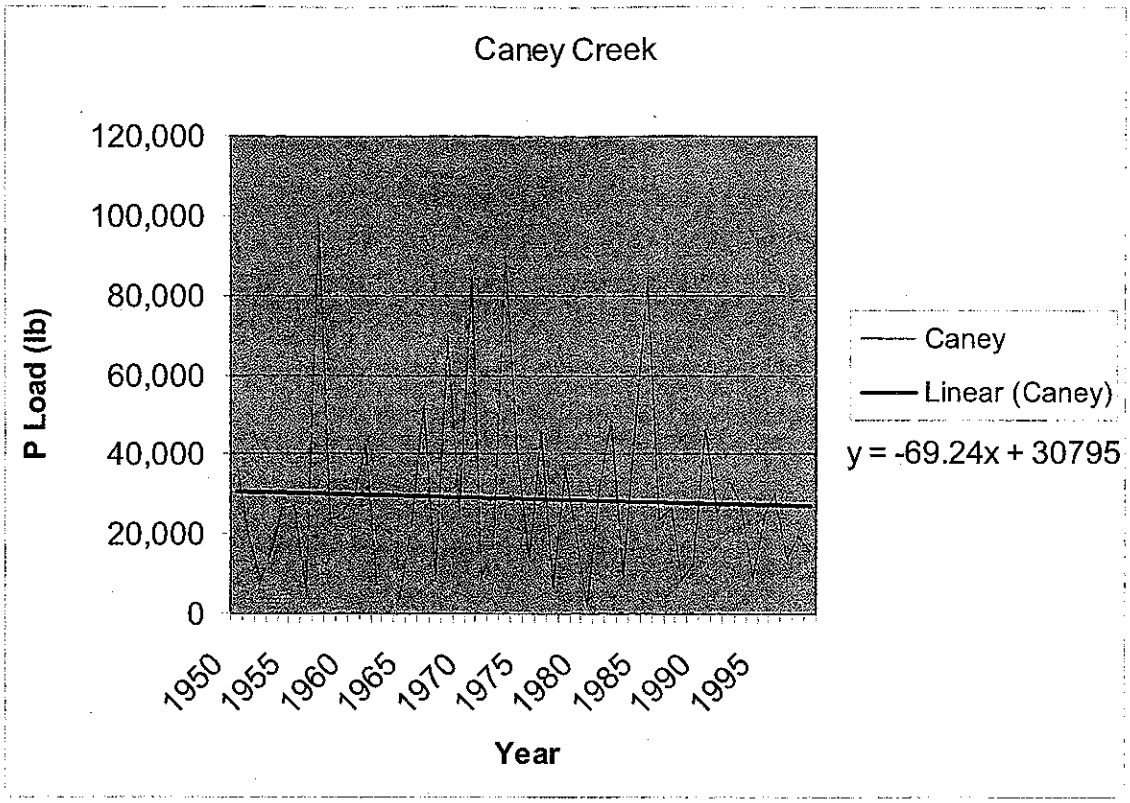

Figure 10.33. Modeled P Load and P Load Trend Line to Caney Creek from 1950 to 1999 Using Observed WWTP P Discharges and IRW Poultry Production

The NPS P loads from 1950 through 1999 are shown in Figures 10.34-10.36 for Tahlequah, Baron Fork at Eldon and Caney Creek. The WWTP P loads were not included in the results shown in Figures 10.34-10.36. The trend lines indicate P loads increase 6,700 lbs annually due to NPS sources. Nearly all of the increased P load is attributable to poultry waste application in the IRW (see P inputs into the IRW as documented in the Mass Balance Analysis in Appendix B).

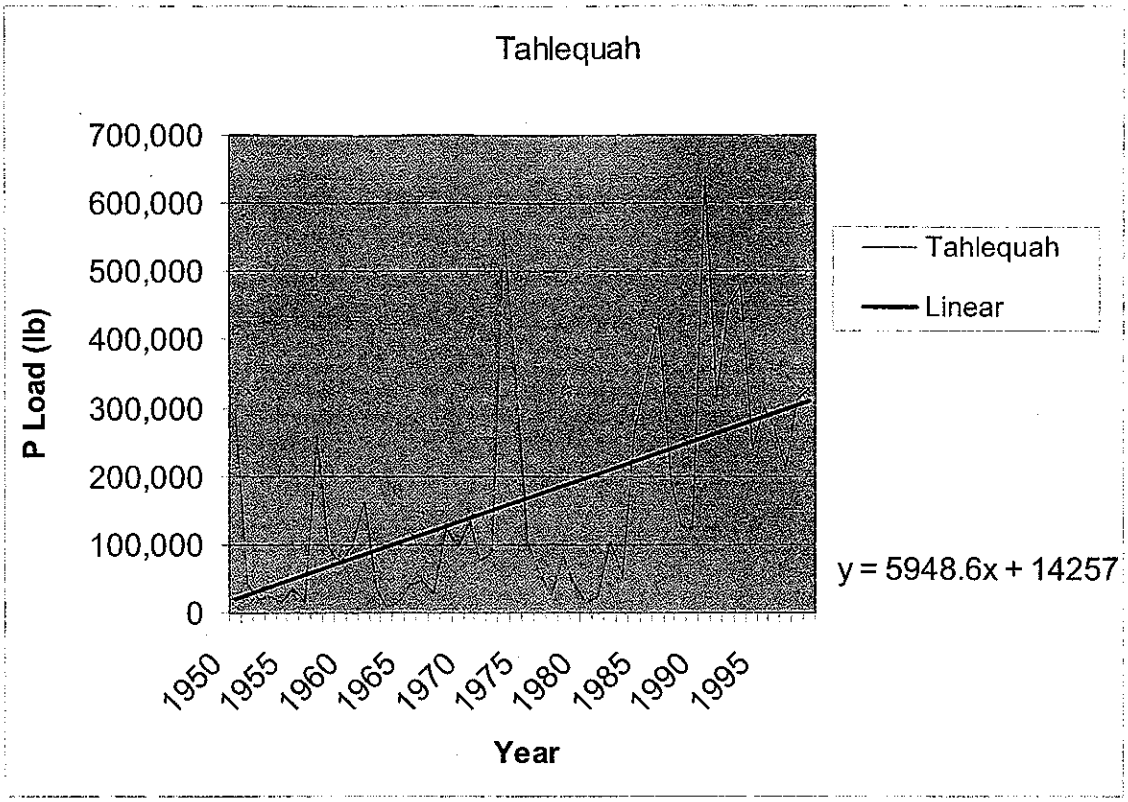

Figure 10.34. Modeled NPS P Load and NPS P Load Trend Line at Tahlequah from 1950 to 1999 Using IRW Poultry Production Data

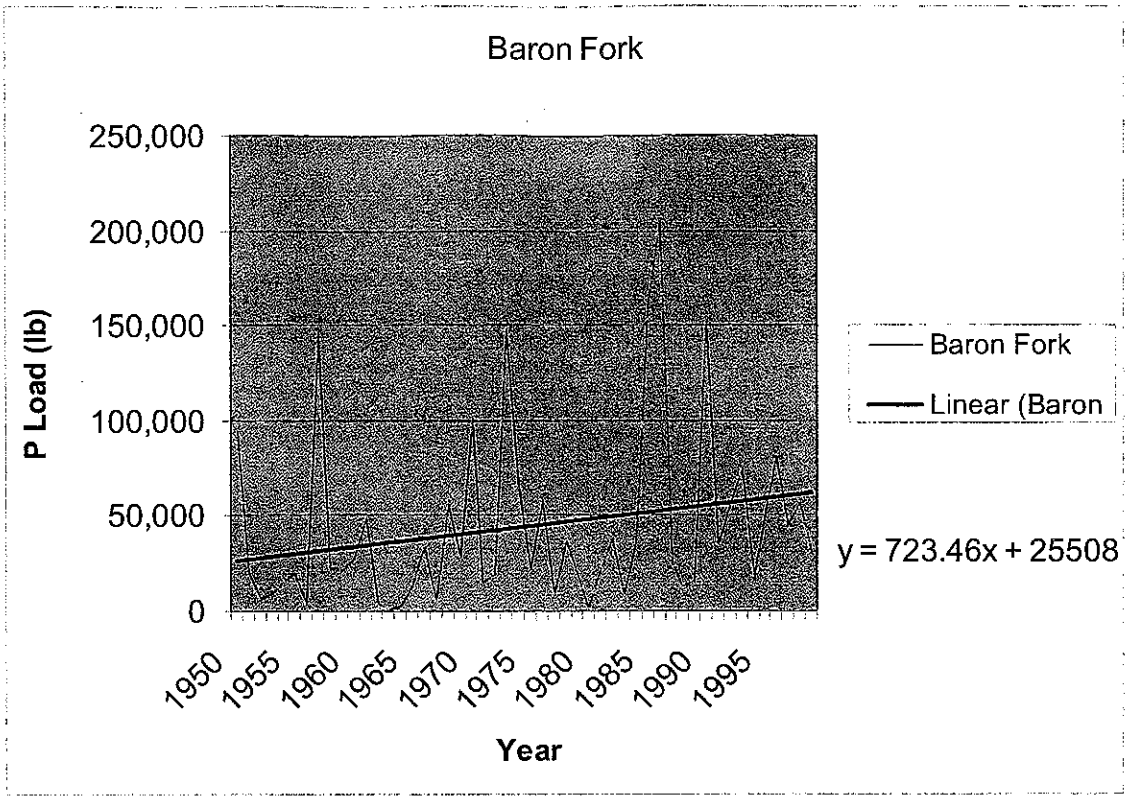

Figure 10.35. Modeled NPS P Load and NPS P Load Trend Line to Baron Fork Near Eldon from 1950 to 1999 Using IRW Poultry Production Data

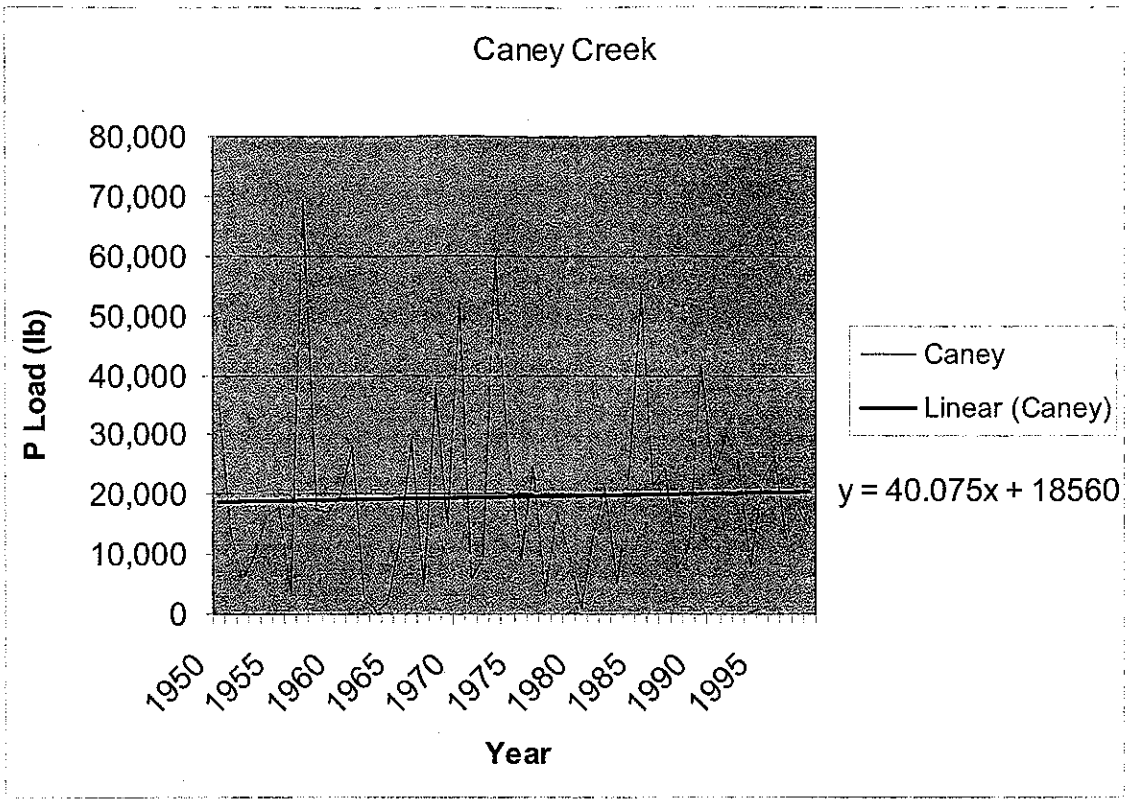

Figure 10.36. Modeled NPS P Load and NPS P Load Trend Line to Caney Creek from 1950 to 1999 Using IRW Poultry Production Data

Average annual historical P concentrations for March-June and July-September were computed for the Tahlequah and Baron Fork locations in support of Dr. Jan Stevens' analysis. Average concentrations were computed based on daily concentrations for each of the analyses periods. Figures 10.37 and 10.38 show P concentrations at Tahlequah for March-June and July-September, respectively. Average concentrations were computed based on daily concentrations for each of the analyses periods. Figures 10.39 and 10.40 show P concentrations at Baron Fork for March-June and July-September, respectively. The P concentration trends for these periods are similar to annual P load trends.

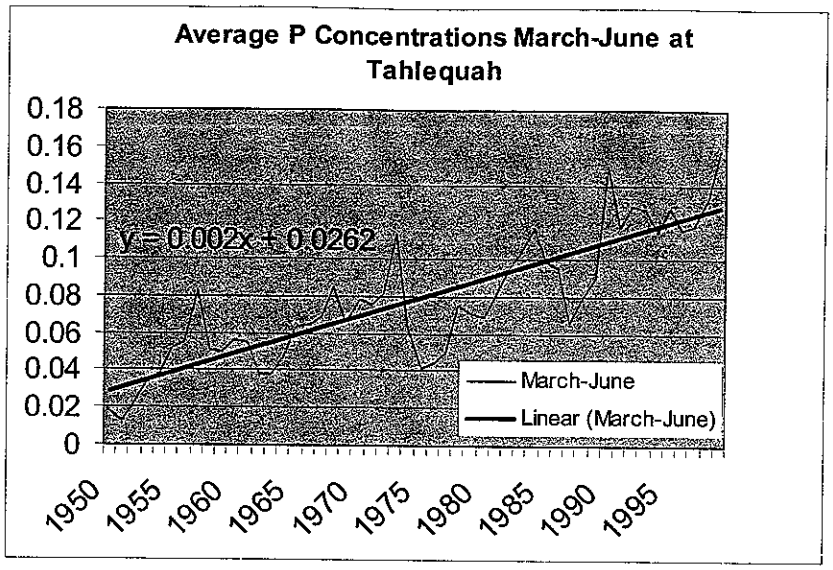

Figure 10.37. Average P Concentrations for March-June Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data

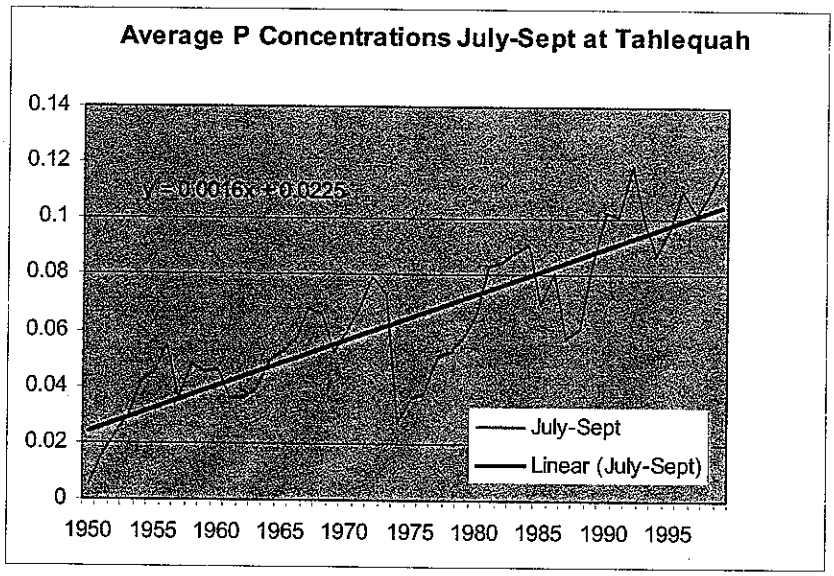

Figure 10.38. Average P Concentrations for July-September Annually at Tahlequah from 1950 Through 1999 Using IRW Poultry Production Data

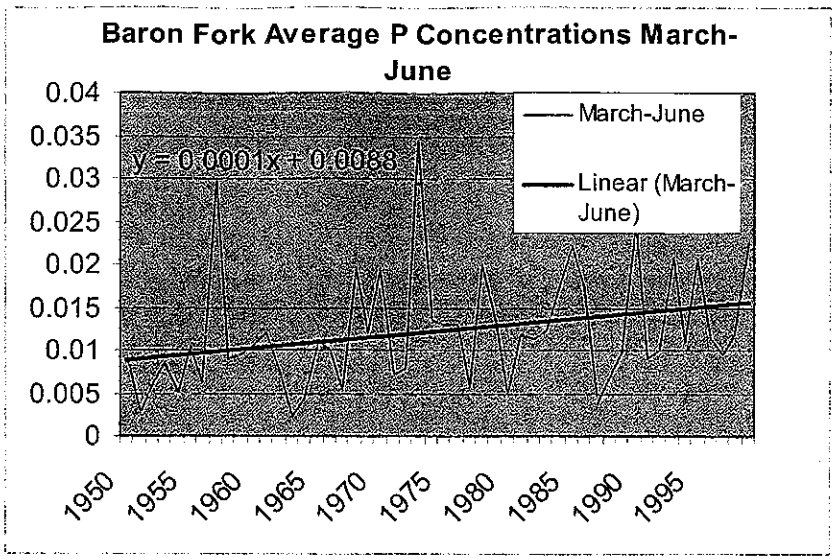

Figure 10.39. Average P Concentrations for March-June Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data

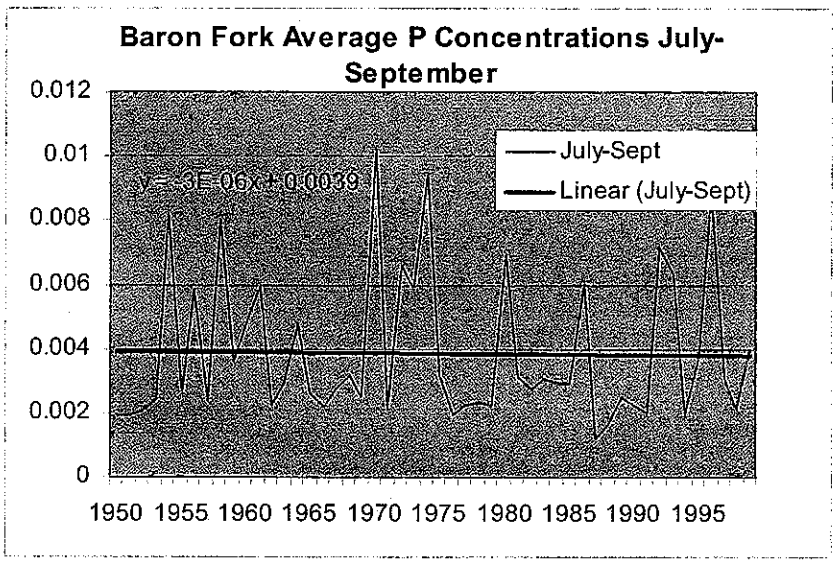

Figure 10.40. Average P Concentrations for July-September Annually at Baron Fork from 1950 Through 1999 Using IRW Poultry Production Data

10.7 Statistical Analysis of P Loads

A statistical analysis of the modeled P loads was conducted to determine if the P loads for the scenarios were statistically different. Both parametric (ANOVA) and nonparametric (Kruskal-Wallis Test) analyses were completed for each of the scenarios at each of the sites (Tahlequah, Baron Fork, and Caney).